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# EXPERIMENTS ON MORTALITY IN HATCHERY-REARED TROUT

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THE UNIVERSITY OF ALBERTA

# EXPERIMENTS ON MORTALITY IN HATCHERY-REARED TROUT

A DISSERTATION
SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES
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by

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# ABSTRACT

A series of experiments was designed and carried out over a three year period to determine the causes of mortality in hatchery-reared trout when planted in mountain streams. Three aspects of this problem were investigated. First, the actual mortality suffered by hatchery-reared trout was determined. Next, the effect of overpopulation of a section of stream on wild native trout was determined. This led to the conclusion that some loss of weight resulted from overstocking but no great mortality occurred. In order to further test this factor, 187 hatchery-reared trout were planted in a section of stream from which the native population had been removed. The mortality occurring in the first few days was very nearly the same as that shown in the first experiment. Thus it appeared that the conditions under which the fish were raised, e.g., hatchery environment, had an adverse effect on their survival. The last experiment was a test of the survival of trout raised in the hatchery to the fingerling stage, and then placed in a barren stream and left to fend for themselves. These fish, when planted in Gorge Creek, behaved much like native trout and suffered no initial mortality.

The effect of stream conditions, e.g., water level, turbidity, and variation of water temperature, was analyzed by comparing day by day mortality with daily records of stream conditions.

The results of the experiments described in this work prove that the planting of trout reared by present hatchery methods in a stream already supporting a population of the same species is uneconomical and does not contribute to the brood stock. It is also shown that trout reared under conditions approximating natural environment show a higher rate of survival when planted in streams.

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# INTRODUCTION

During the past fifteen years the problem of the possibility of restocking lakes and streams with hatchery-reared trout has been of major importance to fisheries management officials. Throughout the United States and Canada plantings have been made on a large scale and in the majority of cases the returns to the angler have been negligible. There are some exceptions to this as in the case of new species introduced to barren waters, the restocking of waters in which some natural catastrophe had wiped out the brood stock, and the introduction of some exotic species. Otherwise, the returns from plantings have been very discouraging. This is especially true of plantings made in the cold, fast-flowing trout streams typical of the Rocky Mountain slopes.

The first research done in Canada to determine the effect of plantings was performed by Dr. R. E. Foerster (1936) of the Pacific Biological Station, Nanaimo, British Columbia. Foerster's experiment, conducted over a ten-year period yielded conclusive evidence that plantings were having little effect on the

commercial salmon catch.

Since Foerster's work was completed many research workers have carried out experiments on many different aspects of survival and other fields of fisheries management. All the workers agree that there is a very great mortality evident in all stream planted trout. The problem is, what causes this serious and rather sudden mortality of hatchery-reared trout when placed in natural waters? Shuck (1948) has listed ten possible causes of the low survivability of hatchery-reared trout; he states:

"1. High percentages of fats and carbohydrates in diets.
2. Overfeeding which leads to (among other things) detrimentally high growth rates.
3. Relative lack of exercise.
4. Artificial conditions where little or no foraging for food is necessary.
5. Relative freedom from predators.
6. Relative stability of water temperature the year round, a condition which does not exist in most trout streams ...... If trout have become accustomed to the rather stable temperatures of the hatchery the more variable temperatures in the wild might contribute to their mortality.

7. Continual domestication of hatchery breeders.
8. Intentional or unintentional selection of fish for good performance in the hatchery, i.e., for rapid growth rate, large production of eggs and like qualities. Such selection does not necessarily produce fish with the qualities to survive in the wild.
9. Relative absence of natural live food......
10. Transportation and planting methods....."

The factors listed above are not necessarily offered as the sole causes of mortality of hatchery fish but it is very likely that they, as a group, deserve major consideration in any attempt to single out causes of mortality.

Needham (1947) through his experiments on the trout populations of Convict Creek, California concluded that variable environmental factors, rather than the number of fry produced by natural spawning in any given season, largely determine the number of fish that later reach catchable size. However, the survival of wild brown trout native to Convict Creek was much higher than hatchery plantings of the same species. Thus the fact that hatchery fish are not as capable of surviving in the wild as native fish is once again demonstrated.

Needham (1950) states that the only sensible method of planting so far, is spring planting of legal sized fish and in-season recovery of these fish in the same year. Of Shuck's ten reasons for mortality in hatchery plantings listed above, Needham says the main ones are:

"1. Strain and heredity of fish.
2. Poor physiological adaptation to withstand hazards of natural environment."

Shetter (1950) says that the only instances where fingerling planting of brook trout in streams might appear to be justified are:

"1. Where angling pressure has been so heavy that insufficient brood stock is left.
2. Where breeders of the stream have been removed by some natural catastrophe.
3. Where suitable spawning conditions do not exist and cannot be created at reasonable cost."

Brasch (1951) describes an experiment on Sawyer Creek on survival of two groups of brown trout planted in October 1950 and March 1951. Collections of fish in the creek were made by the shock method in late April and returns were: 75% wild natives; 17% 1951 (Spring) plants; 8% 1950 (Fall) plants. This once again seems to indicate that spring plants are more effective as a means

of temporarily increasing fish numbers in a creek. It is of general interest that in this experiment, most of the returns were taken within 2,000 feet of one or the other of the planting sites.

The policy of the Canadian Wildlife Service insofar as fish stocking is concerned is outlined by Solman (1951). Stocking in Canada's National Parks is carried out only when:

(1) Natural reproduction is limited or absent.
(2) The fish population in question is wiped out by winter kill or other catastrophe.
(3) A species more adapted to local conditions is being introduced.

From the research reviewed above, it appears evident that indiscriminate planting of hatchery-reared trout has very little beneficial effect on trout populations in general. It is also of interest to note that such plantings cannot be considered a sound financial investment. Thus it is of great importance to all those interested in fisheries management to investigate the causes of mortality in hatchery-reared fish planted in natural waters.

Several experiments have been carried out at Gorge Creek Biological Station over the past three summers for the specific purpose of determining some of the causes of mortality in planted trout. Each of the sections to follow describes a specific experiment which was designed

to illustrate the effect of various factors on hatchery-reared trout.

Section I is a review of the work done by Mangan in 1950. This experiment shows the actual survival of planted trout in Gorge Creek under normal conditions. The mortality and weight losses suffered by these fish are assumed to be very near normal for all plantings of pond-reared trout when planted in mountain streams. The over-winter survival of these fish is reviewed in Section I as are the weight losses shown by the few fish that survived the first winter. Since it was quite evident from the results of this experiment that hatchery-reared trout are not capable of surviving in a mountain stream several other experiments were attempted during 1951 and 1952.

Section II describes an experiment with tagged native trout. A total of 135 native trout were caught, tagged, and transferred to a fish-tight enclosure in which a normal population of wild trout existed. It was thus possible to compare mortality and weight losses of the native trout with the hatchery-reared trout of the previous year. Over population and the possible lack of sufficient food were the factors being investigated. This experiment was carried out during the summer of 1951.

The experiment described in Section III was carried out as a supplement to the previous experiment. It was discovered that the native trout transplanted to a normally populated section did show a slight weight loss, possibly due to the overcrowded condition of the section. Therefore, the normal population of wild trout was removed from an enclosed section of stream and replaced by 187 hatchery-reared trout. The mortality and weight changes shown by this group of fish are described in Section III.

The lack of competition from wild trout did affect the weight losses suffered by the hatchery trout but the mortality remained very nearly the same. This suggested that the mortality was largely due to the previous history of the trout, i.e., life in quiet rearing ponds. In order to test this hypothesis, the survivability of fish raised in fast water was investigated. This experiment is described in Section IV.

The fifth section of this work contains tables showing the mortality and stream conditions each day that the biological station was in operation. This material is presented to show the effect of stream temperatures, water level and turbidity on mortality of trout.

# EXPERIMENTS ON SURVIVAL OF PLANTED TROUT IN GORGE CREEK, ALBERTA.

## I. Hatchery-reared Trout Planted in 1950.

In the spring of 1950 a Biological Experimental Station was set up under the supervision of Dr. R. B. Miller, by the University of Alberta and the Government of the Province of Alberta. The programme for 1950 was designed to determine the actual survival of hatchery-reared trout in a stream which contained a normal population of native trout.

The experiment was planned to illustrate the day by day fate of the planted fish. In order to make these checks on survival possible, three fish-tight screens were installed in the creek at one-half to three-quarter mile intervals. Two sections were thus formed bounded by fish-tight screens. One section was used as a control section and the other was planted with 199 three-year-old cutthroat trout and 201 two-year-old fish of the same species.

A numbered celluloid tag was placed on each side of the fish and attached by a pin through the body. The fish were then weighed individually before planting.

Thus it was possible to keep a record of weight changes of each individual as recaptures were made.

Throughout the summer the section was fished and all tagged fish caught were weighed and returned to the stream. In this way a series of histories was obtained showing changes in weight from planting time until fall.

Mortality. Of the 199 Lot No. 1 (three-year-old) fish there was a total of 30.1 percent known mortality by the middle of August and 44 hatchery fish had been recaptured for weight checks. Thus we shall assume that 69.9 percent of the three-year-old group were in the stream at the end of the summer.

The Lot II (two-year-old) fish did not fare so well in the natural environment. Of these, 47 percent were dead by the 14th day after planting and it was calculated that 87 percent had succumbed by the end of September. Thus only 26 of the original 201 fish entered the winter of 1950-51 in the stream. A detailed account of this work may be found in Mangan (1951).

Weight Changes. The weight changes experienced by these fish are of particular importance as they will be compared with other groups of fish in the sections to follow.

The Lot I (three-year-old) trout lost weight for about 55 days and the planting as a whole decreased gradually to 77 percent of planted weight. The records

of individual fish show that many fell as low as 70 percent and a few as low as 50 percent of planted weight. After the 55th day the average weight began to increase and by the end of the summer, the surviving population was approaching its planted weight. It was noted by Mangan that mortality apparently ceased at the same time as the population as a whole stopped losing weight.

The Lot II (two-year-old) fish also showed a steady drop in weight. The weight loss reached 65 percent of planted weight in 45 days. The observed mortality had reached 50 percent by this time and the actual mortality was calculated to be 80 percent. So few survivors remained that recaptures for weight checks were too infrequent to demonstrate whether the survivors had begun to regain weight or not.

Over-winter Survival and Weight Change. The lowermost fish-tight screen was left in the stream over the winter of 1950-51 and was checked and cleaned periodically by Ranger J. Butler. According to his reports the screen remained intact during the winter and finally washed out on or about April 28th, 1951. It was replaced on May 11th but floods in the ensuing weeks made it impossible to keep it in position until after July 19th. However, any fish which were in the stream over the winter should have

become at home by that time and lost all tendency to drift downstream.

Four months of angling and observation failed to disclose any of the Lot II (two-year-old) fish. A total of seven of the Lot I fish were contacted during the summer of 1951. Five of these were caught in the Sheep River into which they escaped on August 10th, 1950 when the stream flooded during a violent hailstorm. The other two fish were caught in Gorge Creek giving a total survival of 1 percent in the creek itself.

Since none of the Lot II fish was recovered, the total over-winter survival of the 400 fish planted was only 0.5 percent. It is also of interest to note that neither of the two survivors was contacted during the four months the Station was in operation in 1952.

The two fish caught in Gorge Creek were weighed and released. Fish number 223 weighed four ounces when planted and had dropped to three ounces by June 19th, 1951. Number 354 weighed six ounces when planted and on August 16th, 1951 it weighed a fraction of an ounce below this planted weight. Thus the total loss evidenced by these two fish equals 10 percent of planted weight.

All five tagged fish caught in the Sheep River were reported to be very thin and listless, but no accurate weights were obtained. However, it seems

certain that the few fish that survived the winter were of no importance to the population of the stream and therefore the planting was wasted.

## II. Wild Trout Transplanted in 1951.

One of several experiments attempted during the summer of 1951 was the tagging of wild native fish and replanting in another section of the stream. The primary purpose of this work was to overstock a section of stream with wild trout and keep the same type of record of them as was done with the hatchery fish the previous year. It was hoped that some indication of the effect of overstocking would be detected by this method. That is, if the wild natives showed a tendency to lose weight it could be assumed that competition was one of the factors involved in the weight losses suffered by the hatchery fish. A total of 151 fish was caught, tagged, weighed and transferred downstream to the experimental section. This stretch of stream (No. II section), 800 yards in length, was bounded by two fish-tight screens. The screen which bounded the downstream extremity was called Number II screen and the upper one Number III screen.

Mortality. The experiment was hampered by frequent floods throughout the summer and the first 21 fish which were placed in the section escaped during a violent flood shortly after planting. Thus only 135 fish may be counted for the crowding factor. An estimate of the native population of the section involved was made and the figure arrived at was 260 fish. Of the 135 fish planted in Section II, 24 died over a period of 69 days. Of these only three died of natural causes. The remaining 21 were killed by entangling themselves in the webbing of Number III screen while attempting to return to portions of the stream from which they were taken.

The total mortality of these fish was 17.7 percent. This did not occur immediately after planting but was scattered over the whole experimental period. Of this mortality only 2.2 percent is comparable to the mortality suffered by the hatchery-reared fish.

Weight Changes. The weight changes shown by the transplanted native trout and the 1950 hatchery-reared trout (Mangan 1951) are shown for comparison in Table I. The Lot I fish were three-year-old cutthroat trout while the Lot II fish were two-year-olds of the same species.

Table I. Weight changes expressed in percent of planted weight in transplanted native trout and hatchery-reared trout planted in 1950.

| Transplanted Native Trout | | | 3-yr.-old Hatchery-reared Trout | | | 2-yr.-old Hatchery-reared Trout | | |
|---|---|---|---|---|---|---|---|---|
| Days | No. | Av. % Wt. Change | Days | No. | Av. % Wt. Change | Days | No. | Av. % Wt. Change |
| 0-10 | 6 | -7.5 | 0- 10 | 17 | -3.5 | 0- 10 | 85 | -23.6 |
| 11-20 | 14 | -4.5 | 11- 20 | 53 | -13.8 | 11- 20 | 22 | -32.9 |
| 21-30 | 11 | -0.07 | 21- 20 | 26 | -21.9 | 21- 30 | 12 | -37.7 |
| 31-40 | 7 | -4.0 | 31- 40 | 21 | -12.75 | 31- 40 | 5 | -36.2 |
| 41-50 | 5 | +1.0 | 41- 50 | 22 | -17.2 | 41- 50 | 1 | -33.3 |
| 51-63 | 5 | -4.1 | 51- 60 | 10 | -20.4 | 51- 60 | 0 | - |
| | | | 61- 70 | 17 | -14.8 | 61- 70 | 2 | -11.1 |
| | | | 71- 80 | 14 | -9.8 | 71- 80 | 0 | - |
| | | | 81- 90 | 8 | -10.85 | 81- 90 | 0 | - |
| | | | 91-100 | 2 | -0.26 | 91-100 | 0 | - |

The number of fish captured and weighed in the above table includes both live recaptures and those fish which died and were weighed during the ten day periods listed. Since a much higher percentage of hatchery fish died during the experiment than did the natives a greater number of weights were obtained.

The weight losses suffered by the hatchery-reared fish are significantly higher than those suffered by the native trout. The Lot II (two-year-old) trout show a consistent and very high weight loss. Many of the native fish placed in Enclosure II in 1951 were much smaller than the Lot II fish but showed no such drastic weight loss or mortality ratio.

Thus, although the overcrowded condition of the enclosure may have a slight effect on weight loss, as shown by native trout, it does not account entirely for the tremendous weight losses suffered by the hatchery-reared fish or for the very heavy mortality.

Over-Winter Survival. The most interesting facet of this experiment was discovered during the summer of 1952. The screens were removed from the creek in September 1951, thus allowing the fish to move freely up or down the stream. At this time the known mortality of these tagged native trout had reduced the number present in the creek to 121.

During the summer of 1952 the stream was fished extensively and records of 48 of these fish were obtained. Three consisted of tags only, found on the stream bottom; 11 were captured in Enclosure II and killed to remove competition with hatchery fish; 33 were captured in Enclosure III or above it and were released.

These 44 recoveries represent a proven survival over the winter of 36.3 percent. In the 1951 report of the Alberta Biological Station, an experiment is described which led to the calculation of 36.3 percent over-winter survival of native trout. This checks exactly with the minimum or proven survival as noted above.

However, this is a minimum survival. It is possible that some tagged native trout escaped capture. A fairly accurate estimate of the number of fish actually present in the stream may be obtained by using the formula devised by Schumacher and Eschmeyer (1943) for population determinations based on recaptures of tagged fish. This formula is $P = \Sigma(AB^2) / \Sigma(BC)$ where P equals population, A equals the daily catch of fish, B equals marked fish at large, and C equals recaptures of marked fish. In the present case A means captures of marked fish, B is the cumulative total of tagged fish captured and released, and C means marked fish captured two or more times. The data arranged for this calculation are presented in Table II.

Table II. Estimate of population of tagged native trout in Gorge Creek in 1952.

| Date | A | C | B | $B^2$ | $AB^2$ | BC |
|---|---|---|---|---|---|---|
| May 23 | 1 | 0 | 1 | 1 | 1 | 0 |
| June 4 | 3 | 0 | 3 | 9 | 27 | 0 |
| " 5 | 2 | 0 | 3 | 9 | 18 | 0 |
| " 6 | 3 | 0 | 4 | 16 | 48 | 0 |
| " 7 | 1 | 0 | 5 | 25 | 25 | 0 |
| " 9 | 1 | 0 | 5 | 25 | 25 | 0 |
| " 11 | 1 | 0 | 5 | 25 | 25 | 0 |
| " 20 | 2 | 1 | 6 | 36 | 72 | 6 |
| July 3 | 7 | 0 | 13 | 169 | 1183 | 0 |
| " 4 | 3 | 2 | 13 | 169 | 507 | 26 |
| " 13 | 2 | 0 | 15 | 225 | 450 | 0 |
| " 15 | 1 | 0 | 16 | 256 | 256 | 0 |
| " 18 | 2 | 1 | 17 | 289 | 578 | 17 |
| " 28 | 5 | 2 | 20 | 400 | 2000 | 40 |
| " 31 | 4 | 2 | 21 | 441 | 1764 | 42 |
| August 4 | 1 | 0 | 21 | 441 | 441 | 0 |
| " 14 | 2 | 1 | 22 | 484 | 968 | 22 |
| " 17 | 1 | 0 | 23 | 529 | 529 | 0 |
| " 20 | 1 | 1 | 23 | 529 | 529 | 23 |
| " 21 | 1 | 1 | 23 | 529 | 529 | 23 |
| " 23 | 2 | 2 | 23 | 529 | 1058 | 46 |
| " 31 | 2 | 2 | 23 | 529 | 1058 | 46 |
| September 8 | 1 | 1 | 23 | 529 | 529 | 23 |
| " 15 | 6 | 3 | 26 | 676 | 4056 | 78 |
| " 17 | 2 | 1 | 27 | 729 | 1458 | 27 |
| " 18 | 9 | 4 | 32 | 1024 | 9216 | 128 |
| November 2 | 5 | 4 | 33 | 1089 | 5445 | 132 |
|  |  |  |  |  | 33795 | 679 |

$$\frac{33795}{679} = 49.8 \text{ fish present}$$

$$\frac{50}{121} = 41.3\% \text{ survival}$$

Applying the formula, P = 33,795/679 = 49.8 fish, which is rounded off to 50 fish, the estimate of survival becomes 50/121 = 41.3 percent.

This method of calculating the number of tagged, wild fish present in Gorge Creek during the summer of 1952 shows that approximately 50 fish survived the winter months. Thus the survival would be 41.3 percent. The survival over the winter of 1951-52 was therefore, 5 percent higher than in 1950-51.

Weight Change of Survivors. All of the fish of this group caught in 1952 were weighed. Altogether 26 fish were weighed once, eight twice, nine three times, and one four times. The weight changes evidenced by these fish are arranged in Table III to show influence of original weight on total change.

Table III. Weight changes in wild trout, tagged and weighed in June-July, 1951, and reweighed in 1952; data arranged according to original weights of fish.

| Original Weight (ounces) | No. of Fish | Average Increase in Weight (%) |
|---|---|---|
| 0 - 1 | 2 | 87.5 |
| 1¼ - 2 | 15 | 44.7 |
| 2¼ - 3 | 7 | 17.5 |
| 3¼ - 6 | 13 | 8.1 |

Table III shows that the smaller fish grow much more rapidly than the larger, older ones.

The weight changes evidenced by these fish throughout the summer with respect to their original weight is next considered. The data are arranged by months of recapture and show percent weight change of all fish recaptured during each period. Table IV shows the number of fish caught during the three periods, the number of fish showing gains in weight, the number of fish showing losses, and the average weight change in percent of planted weight. It may be noted that in all cases the average weight change is an increase over average planted weight.

Table IV. Weight changes in wild trout tagged and weighed in June-July, 1951 and reweighed in 1952. Data arranged by months of recapture.

|  | No. of Fish | Gains | Losses | Average Increase |
|---|---|---|---|---|
| May - June | 15 | 8 | 4 | 5.1% |
| July | 18 | 16 | 1 | 13.6% |
| August - September | 24 | 21 | 1 | 28.5% |

Table IV shows that all but six fish gained in weight, and as the summer lengthened the amount gained increased.

## III. Hatchery-reared Trout in Absence of Competition from Wild Trout.

This experiment was planned in order to ascertain the effect, if any, of competition with wild native fish on survival and growth of hatchery-reared trout. Mangan (1951) noted that wild trout often took food from the slower moving hatchery fish in a stream and suggested this as one of the causes for weight losses observed. Therefore, the impounding of hatchery fish in a section of stream from which the native population had been removed was carried out and histories of individual fish were compiled.

The section of stream in which the fish were planted was about one-half mile in length and was bounded at either end by fish-tight screens. In order to remove the native fish from the section of stream it was necessary to concentrate fishing pressure on the section for several weeks. It is of interest to note that although the section was heavily fished over a four month period and a total of 190 fish was removed, some native trout were still present in late September. Thus it appears impossible to remove the entire population of a stream by fishing pressure alone.

However, since 190 native trout were removed from the section and 188 hatchery-reared trout were planted, the population of the section remained constant and over-population or shortage of food could not be considered a factor.

Table V. shows the numbers of native fish removed and the dates of removal.

Table V. Numbers of native fish removed from Section II and dates of removal.

| | |
|---|---|
| June 4 - June 11 (day of first planting | 73 |
| June 12 - July 14 (day of second planting | 59 |
| July 15 - 31 | 23 |
| August | 18 |
| September | 17 |
| TOTAL: | 190 |

The first group of 143 hatchery fish was planted on June 11, 1952 and 18 fish were found dead on that date. Heavy rain during the night caused the creek to flood and wash out all the screens. In July and early August five of these fish were caught in the Sheep River; three more were caught in Gorge Creek and one was found dead in Gorge Creek on July 14, 1952.

Thus a total of 27 (19%) of these fish was recovered and of these only three were caught in the area in which the native population was reduced. Thus the first attempt was not successful.

Mortality. The flood conditions in Gorge Creek had subsided by the end of June and on July 14th, 1952, 187 two-year-old trout from McLeod rearing ponds were released in the prepared section. These fish bore tag numbers 383-578 and 904 (omitting 418, 438, 439, 454, 462, 467, 490, 491, 502 and 527 - lost while being loaded onto packhorses).

Several of the fish were in very poor condition on delivery although they had spent a maximum of only five hours in the hatchery truck tank. The planting was accomplished by pack-horse with the invaluable assistance of Ranger Wm. Balmer.

Within two hours after planting was completed, six fish had died and drifted downstream to the lower screen. During the first 24 hours after planting a total of 67 (35.8%) fish had died. Of these, 55 were found dead on the lower screen, seven were dead along the banks of the stream and five had killed themselves attempting to travel upstream through Number III screen.

In the period July 14 to July 22, 102 (54.4%) of these fish died and either caught on Number II screen or were picked up dead in the enclosure. Five more were found dead in the upper screen bringing the total mortality to 107. In the period July 23 to September 19, another 17 died and were recovered in the section. This raised the total mortality to 124. However, ten of these fish killed themselves on Number III screen while attempting to move upstream and cannot be counted as natural mortality. Thus 114 (60.9%) of these fish died over the experimental period. This figure is not significantly different from the 57% mortality observed in similar fish planted in the same creek in 1950 (Mangan 1951).

The main difference is that the bulk of the mortality in the 1952 experiment occurred in the first 48 hours after planting. This may be explained by the position of the lower screens in the two sections used. It has been observed that most hatchery fish when placed in fast flowing water seem bewildered and tend to drift downstream until they encounter an obstruction, such as a screen, in the water.

In the 1950 experiment the lower screen was situated immediately below a large deep pool. Large numbers of fish drifted down the creek, encountered the screen

and then swam a few feet back upstream and rested in the relatively slow moving water of the pool. Many of these fish survived for several days before finally succumbing to the current and dying on the screen. Thus the mortality was spread over several days. The 20 yards of stream immediately above the lower screen in the 1952 experiment were shallow and rapid offering no pools in which the fish could rest after once encountering the screen. Thus the mortality due to exhaustion was very nearly the same as in the 1950 experiment but concentrated into a shorter period of time.

Several of the planted trout travelled upstream rather than drifting down and so encountered Number III screen. Five of the ten fish that killed themselves by becoming entangled in Number III screen were dissected and their stomach contents examined. Recently devoured insects were noted in all five stomachs whereas no food material of any kind was found in the stomachs of fish that died and drifted to the lower screen. Thus it appears that a small percentage (5.2% in this case) of hatchery-reared fish are capable of feeding and moving freely in fast water as soon as they are planted.

Weight Changes. In the period July 28 to September 17, twelve of the surviving fish were caught by angling, weighed, and returned to the stream. The record of weight changes experienced by these fish is shown in Table VI.

Table VI. Weight changes in percent of planted weight of 12 hatchery-reared trout in Enclosure II.

| No. of Fish | Gain (%) | No. of Fish | Loss (%) |
|---|---|---|---|
| 2 | 25.0 | 1 | 5.0 |
| 1 | 14.3 | 1 | 6.2 |
| 1 | 8.3 | 1 | 14.3 |
| 2 | 0.0 | 1 | 15.4 |
| | | 1 | 15.6 |
| | | 1 | 28.6 |

Table VI shows that four fish gained weight, two showed no change and six lost weight. The average for the 12 fish is a loss of 1.04 percent. This is considerably less than the 35 percent loss suffered by similar fish with native competition in 1950. (Mangan 1951).

It is conclusively shown, however, that the very large natural mortality is not lessened by the absence of wild trout. Thus native competition is not a factor in mortality evidenced by planted trout during the first few days after planting.

The few survivors in this experiment lost considerably less weight than those competing with native trout but due to the few returns available this cannot be taken as conclusive evidence that the presence of native fish is a factor in the weight losses suffered by hatchery fish.

## IV. Survival of Trout Reared at Bighill Springs.

Bighill Creek arises from the confluence of several springs that bubble out of the ground in a valley approximately two miles northeast of Cochrane, Alberta (N.W. Quarter, Section 29, Township 26, Range 3, West of the 5th Meridian). The creek is a tributary of the Bow River. The hatchery at Bighill Springs was constructed by the Alberta Government in the summer of 1951 and maintained during the following winter. The main project undertaken by the hatchery was the "eyeing" of cutthroat eggs during the winter months. The fish which were planted in Gorge Creek were at that time in Bighill Creek.

In May 1949 a number of cutthroat trout eggs were obtained from Spray Lakes and hatched in the Calgary Hatchery during the week ending July 9th, 1949. In May 1950 the fry were removed to Westmount rearing ponds and retained there until September 1st, 1950 at which time they were planted in two ponds in Bighill Creek. At that time the fish averaged about 25 fish per pound and numbered about 600. There were some rainbow trout in this group, representing a surplus from Westmount ponds after summer planting operations had ceased.

From September 1st, 1950 to June 5th, 1952 these fish were left in the stream to fend for themselves. No artificial feeding was practised although the fish were observed frequently by hatchery staff.

The two pools in which the fish were planted are both fed by waterfalls about eight feet in height. A screen was installed across the outlet of the lower pool in an effort to stop downstream movement of the fish. No tendency to drift downstream was noted in either group until their increased size necessitated increased movement in search of food.

Bighill Creek contained no native fish population at the time of planting although surveys revealed sufficient food and other conditions favorable to a trout population. The oxygen concentration was found to be 6.0 to 6.5 cc. per litre (abundant) and the pH range was 6.5 to 7 (neutral). The water temperature varies between 32° F. and 45° F. over the year. The rate of flow is approximately 2.5 feet per second and the volume of flow about 2,000 gallons per minute. Analysis of water from below the hatchery showed favorable comparison with proved trout streams.

Thus the fish were subjected to natural conditions and forced to obtain their own food. It was

hoped that this procedure would produce a hardier fish at less cost to the hatchery.

Removal of the fish from the creek was accomplished June 5th and 6th, 1952, by diverting portions of the stream, pumping the pools dry, and then placing the fish in the hatchery tank truck. A total of 69 fish was taken in this manner and transported to the Calgary hatchery where they were individually weighed and tagged.

On June 9th, 1952, fifty-eight of the fish were transported to Gorge Creek where they were replanted in an experimental section. Of the 58 fish delivered to Gorge Creek, 56 were Cutthroat and two were Eastern Brook trout. The section of creek in which they were placed was approximately one-half mile in length and bounded by two fish-tight screens. This section of stream contained the normal population of wild native trout which was later augmented by the addition of 58 hatchery-reared trout.

This produced the same conditions as experienced by the hatchery fish planted by Mangan in 1950, and a comparison of mortality rate was intended. It was also hoped to keep a day by day comparison of Bighill reared trout and the pond reared fish as to weight changes, mortality, etc. Heavy rains for several days following planting caused the stream level to rise rapidly and the screens were washed out. All the portions of the screens which

remained in the creek were removed and not replaced until July 6th thus giving the fish 25 days in which to move freely in the creek.

During the summer 33 of the Bighill fish were contacted; of these, 29 were caught by angling, three were found dead in the creek, and one fish died attempting to travel upstream through No. IV screen shortly after planting. Weight checks were obtained on 32 of the 33 fish contacted as one of the fish which died in the creek had decomposed and only the tags were found.

Mortality. Since only three of the Bighill fish were known to have died of natural causes the natural mortality equaled 5.2 percent. In addition to the fish found dead, three were caught and killed by anglers; one near the mouth of Gorge Creek, and two in the Sheep River. The total known mortality in 1952 is, therefore, 12.1 percent.

In order to estimate the number of Bighill trout that escaped into the Sheep River, the catch records of the Bighill fish caught in Gorge Creek were treated as a tagging experiment and calculations made according to Schumacher and Eschmeyer (1943) (as in Section II). The formula previously explained (Section II) was used to

calculate the number of Bighill trout in Gorge Creek. The figures obtained and calculations made are shown in Table VII.

Table VII. Estimate of population of Bighill reared trout in Gorge Creek in 1952.

Population = $\Sigma(AB^2) / \Sigma(BC)$

| Date | Catch A | Recaptures C | No. caught & released | No. caught & released (cumulative) B | $B^2$ | $AB^2$ | BC |
|---|---|---|---|---|---|---|---|
| June 11 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20 | 2 | 0 | 1 | 1 | 1 | 2 | 0 |
| July 3 | 2 | 0 | 2 | 3 | 9 | 18 | 0 |
| 5 | 1 | 0 | 1 | 4 | 16 | 16 | 0 |
| 6 | 1 | 1 | 1 | 4 | 16 | 16 | 4 |
| 12 | 3 | 0 | 3 | 7 | 49 | 147 | 0 |
| 13 | 1 | 0 | 1 | 8 | 64 | 64 | 0 |
| 14 | 1 | 0 | 0 | 8 | 64 | 64 | 0 |
| 15 | 3 | 0 | 3 | 11 | 121 | 363 | 0 |
| 16 | 1 | 1 | 1 | 11 | 121 | 121 | 11 |
| 18 | 2 | 1 | 2 | 12 | 144 | 288 | 12 |
| 24 | 1 | 0 | 1 | 13 | 169 | 169 | 0 |
| 28 | 4 | 2 | 4 | 15 | 275 | 900 | 30 |
| 31 | 4 | 2 | 4 | 17 | 289 | 1156 | 34 |
| Aug. 6 | 1 | 0 | 0 | 17 | 289 | 289 | 0 |
| 8 | 3 | 1 | 2 | 19 | 361 | 1083 | 19 |
| 14 | 1 | 1 | 1 | 19 | 361 | 361 | 19 |
| 19 | 2 | 2 | 2 | 19 | 361 | 722 | 38 |
| 21 | 3 | 2 | 3 | 20 | 400 | 1200 | 40 |
| 23 | 1 | 1 | 1 | 20 | 400 | 400 | 20 |
| 31 | 4 | 4 | 4 | 20 | 400 | 600 | 80 |
| Sept. 8 | 1 | 1 | 1 | 20 | 400 | 400 | 20 |
| 15 | 3 | 2 | 3 | 21 | 441 | 1323 | 42 |
| 17&18 | 8 | 2 | 8 | 27 | 729 | 5832 | 54 |
|  |  |  |  |  |  | 16534 | 423 |

$$P = \Sigma(AB^2) / \Sigma(BC) = \frac{16534}{423} = 39.08$$

Applying the formula, P = 16534/423 = 39.08 fish, which is rounded off to 39 fish. Thus it is shown that 39 of these fish remained in Gorge Creek and 19 drifted downstream into the Sheep River. Of the 19 fish calculated to be in the Sheep River, two were caught in the summer of 1952. One of these was upstream from the mouth of Gorge in the Sheep River.

Weight Changes. During the summer 29 Bighill trout were caught by angling, weighed, and released. Weight checks were obtained on three other fish found dead in the stream. The data obtained from these checks provide a record of weight changes after transfer to the new environment and competition with wild native trout. The 32 weight checks have been divided into two periods; the first fifty days following planting, and the second fifty days following planting. The data are shown in Table VIII.

Table VIII. Record of weight changes in Bighill reared trout (percent of planted weight).

| 0 - 50 days | | 51 - 100 days | |
|---|---|---|---|
| Number | Weight change (%) | Number | Weight change (%) |
| 4 | 0 | 5 | 0 |
| 1 | -30.0 | 2 | -6.3 |
| 2 | -12.5 | 1 | -7.1 |
| 1 | +12.5 | 4 | -12.5 |
| 1 | +16.7 | 1 | -25.0 |
| 1 | +50.0 | 2 | +12.5 |
| Average = | +2.4% | 1 | +14.3 |
| | | 2 | +16.7 |
| | | 2 | +20.0 |
| | | 1 | +45.0 |
| | | 1 | +75.0 |
| | | Average = | +6.3% |

Table VIII shows that the average weight of the Bighill fish increased during the whole summer. However, it should be noted that seven of the ten fish

caught in the first fifty days after planting showed a weight loss or no change from planted weight. The average weight of the group was greatly influenced by the percentage gain in weight of three fish.

The 22 fish caught during the second fifty days after planting show a greater percentage of fish gaining weight but there are still more fish showing no change or a weight loss than gains.

Of the 57 pond reared trout released in the same enclosure as the Bighill fish, nine were contacted during the summer. Four were found dead on Number III screen after the June floods, four others were caught in various parts of Gorge Creek, and one was caught in the Sheep River three miles downstream from the site of planting. It is, therefore, quite evident that the Bighill reared trout were a much hardier and more successful group than the pond reared trout.

## V. Effect of Stream Conditions on Survival of Trout.

Gorge Creek is a typical mountain stream, subject to intermittent floods and periods of high turbidity. These two factors are usually, but not invariably, concurrent. Turbidity occasionally occurs with little or no rise in water level. The following tables show the water levels, stream temperatures, degree of turbidity of the stream, and mortality experienced by marked fish known to be in the creek over the periods involved.

These records were collected during the summers of 1950, 1951 and 1952.

Table IX shows stream conditions and mortality of hatchery-reared trout in 1950; Table X gives the same data for 1951 except that wild transplanted trout were under observation; and Table XI shows stream conditions and mortality of hatchery-reared trout which had no competition from wild trout.

The terms used to describe the turbidity of the stream are not technical but give a general indication of the condition of the water in each case.

Table IX. Hatchery-reared trout 1950 - Mortality - Stream Conditions.

| Date | Total No. Present | Mortality | | Temperature | | Stream Level | Turbidity |
|---|---|---|---|---|---|---|---|
| | | No. | % | Min. | Max. | | |
| ne 16 | 199 | 0 | 0 | 43 | 50 | 9.75 | Very murky |
| 17 | 199 | 0 | 0 | 41 | 51 | 11.00 | Muddy |
| 18 | 199 | 3 | 1.57 | 38 | 57 | 9.50 | Very murky |
| 19 | 196 | 2 | 1.02 | 40.5 | 54 | 9.50 | " " |
| 20 | 194 | 0 | 0 | 42 | 60 | 9.50 | Murky |
| 21 | 194 | 1 | 0.51 | 44 | 53 | - | Slightly murky |
| 22 | 193 | 0 | 0 | 43 | - | 8.00 | " " |
| 23 | 193 | 0 | 0 | 41 | 43 | 8.50 | Clear |
| 24 | 193 | 0 | 0 | 40 | 46 | 7.00 | Clear |
| 25 | 193 | 2 | 1.03 | 40 | 51 | 6.50 | " |
| 26 | 191 | 2 | 1.04 | 40.5 | 55 | 6.25 | " |
| 27 | 189 | 4 | 2.11 | 41 | 53 | 5.50 | " |
| 28 | 185 | 5 | 2.70 | 43 | 55 | - | " |
| 29 | 180 | 6 | 3.33 | - | - | 5.00 | " |
| 30 | 174 | 7 | 4.02 | 45 | 59 | 4.50 | " |
| ly 1 | 176 | 2 | 1.19 | 47 | 60 | 4.00 | " |
| 2 | 165 | 4 | 2.42 | 47 | 59 | 4.00 | " |
| 3 | 161 | 2 | 1.24 | 47 | 55 | 3.75 | " |
| 4 | 159 | 2 | 1.25 | 46 | - | - | " |
| 5 | 358 | 1 | 0.28 | 45.5 | 57 | - | " |
| 6 | 357 | 2 | 0.56 | 47 | 59 | 3.75 | " |
| 7 | 355 | 1 | 0.28 | 43.5 | 60 | 3.50 | Murky |
| 8 | 354 | 4 | 1.12 | 49 | 60 | 3.50 | " |
| 9 | 350 | 11 | 3.14 | 47 | 61 | 3.25 | Clear |
| 10 | 339 | 17 | 5.01 | 47 | - | 3.25 | " |
| 11 | 322 | 23 | 7.14 | 46 | - | 3.25 | " |
| 12 | 299 | 14 | 4.68 | 43 | 60 | 3.50 | " |
| 13 | 285 | 11 | 3.85 | 47 | 58 | 2.75 | " |
| 14 | 274 | 4 | 1.45 | 46 | 56 | 3.50 | Very muddy |
| 15 | 269 | 5 | 1.85 | 46 | 50 | 3.50 | Murky |
| 16 | 263 | 3 | 1.14 | 45 | 52 | 3.00 | " |
| 17 | 260 | 4 | 1.53 | 46 | 59 | 3.75 | Slightly murky |
| 18 | 256 | 0 | 0 | 43 | 63 | 3.50 | " " |
| 19 | 256 | 3 | 1.17 | 47 | - | - | " " |
| 20 | 253 | 0 | 0 | 45 | 59 | 3.75 | " " |
| 21 | 253 | 3 | 1.18 | 48 | 61 | 3.00 | Clear |
| 22 | 250 | 1 | 0.40 | 46 | 62 | 3.00 | " |
| 23 | 249 | 1 | 0.40 | 46 | 63 | 3.00 | " |
| 24 | 248 | 0 | 0 | 48 | - | 3.00 | Murky |
| 25 | 248 | 0 | 0 | 47 | 63.5 | 2.25 | Slightly murky |
| 26 | 248 | 1 | 0.40 | 49 | 63.5 | 2.50 | " " |
| 27 | 247 | 0 | 0 | 50 | 67 | 2.25 | " " |
| 28 | 247 | 2 | 0.80 | 51 | 54 | 2.25 | Clear |
| 29 | 245 | 6 | 2.44 | 46 | 47 | 6.50 | Murky |
| 30 | 239 | 7 | 2.92 | 40 | 56 | 4.75 | " |
| 31 | 232 | 0 | 0 | 47 | 62 | 3.75 | Slightly murky |

Table IX. Continued.

| ate | Total No. Present | Mortality No. | Mortality % | Temperature Min. | Temperature Max. | Stream Level | Turbidity |
|---|---|---|---|---|---|---|---|
| . 1 | 232 | 1 | 0.43 | 44 | 64 | - | Slightly murky |
| 2 | 231 | 0 | 0 | 47 | - | - | " " |
| 3 | 231 | 0 | 0 | 48 | 51 | 3.00 | " " |
| 4 | 231 | 0 | 0 | 46 | 57.5 | 3.25 | " " |
| 5 | 231 | 2 | 0.86 | 44 | 60 | 2.50 | Clear |
| 6 | 229 | 0 | 0 | - | 58 | 2.50 | " |
| 7 | 229 | 0 | 0 | 46 | 58 | - | " |
| 8 | 229 | 1 | 0.43 | 47 | 57 | - | " |
| 9 | 228 | 0 | 0 | 48 | 56 | 2.75 | " |
| 10 | 228 | 1 | 0.43 | 46 | 38 | 7.50 | Muddy |
| 11 | 227 | 1 | 0.44 | 45 | 56 | 4.50 | " |
| 12 | 226 | 0 | 0 | 46 | 58 | 3.75 | Murky |
| 13 | 226 | 1 | 0.44 | - | 63 | 3.25 | Slightly murky |
| 14 | 225 | 1 | 0.44 | 49 | 53.5 | 3.00 | " " |
| 15 | 224 | 1 | 0.44 | 49 | 57 | 3.00 | " " |
| 16 | 223 | 0 | 0 | 46 | - | 3.00 | " " |
| 17 | 223 | 0 | 0 | 42 | 57 | 3.00 | Clear |
| 18 | 223 | 0 | 0 | 47 | 47.5 | - | " |
| 19 | 223 | 0 | 0 | 42 | 59 | - | " |
| 20 | 223 | 0 | 0 | 44 | 59 | 2.25 | " |
| 21 | 223 | 0 | 0 | 47 | 59 | 2.25 | " |
| 22 | 223 | 0 | 0 | 47 | 60 | 2.00 | " |
| 23 | 223 | 0 | 0 | 50 | 50 | 2.00 | " |
| 24 | 223 | 0 | 0 | 48 | 57 | 2.00 | Slightly murky |
| 25 | 223 | 0 | 0 | 50 | 58 | 2.00 | Clear |
| 26 | 223 | 0 | 0 | - | 56 | 2.25 | " |
| 27 | 223 | 0 | 0 | 48 | 50.5 | 2.00 | Murky |
| 28 | 223 | 1 | 0.44 | 42.5 | 58 | 2.00 | Slightly murky |
| 29 | 222 | 0 | 0 | 48 | 57 | 1.75 | Clear |
| 30 | 222 | 0 | 0 | 48 | 56 | 1.75 | " |
| 31 | 222 | 0 | 0 | 46.5 | - | 1.75 | " |
| t. 1 | 222 | 0 | 0 |  |  | 1.75 | " |
| 2 | 222 | 0 | 0 |  |  | 1.75 | " |
| 3 | 222 | 0 | 0 |  |  | 2.00 | " |
| 4 | 222 | 0 | 0 |  |  | 2.00 | " |
| 5 | 222 | 0 | 0 |  |  | 2.00 | " |
| 6 | 222 | 0 | 0 |  |  | - | " |
| 7 | 222 | 0 | 0 |  |  | - | " |
| 8 | 222 | 0 | 0 |  |  | 2.00 | " |
| 9 | 222 | 0 | 0 |  |  | 2.00 | " |
| 10 | 222 | 0 | 0 |  |  | 2.00 | " |
| 11 | 222 | 0 | 0 |  |  | 2.00 | " |
| 12 | 222 | 0 | 0 |  |  | 2.00 | " |
| 13 | 222 | 0 | 0 |  |  | 2.00 | " |
| 14 | 222 | 0 | 0 |  |  | 2.00 | " |

Table IX. Concluded.

|  | Total No. | Mortality |  | Temperature |  |  |  |
|---|---|---|---|---|---|---|---|
| Date | Present | No. | % | Min. | Max. | Stream Level | Turbidity |
| t. 15 | 222 | 1 | 0.45 |  |  | 2.00 | Clear |
| 16 | 221 | 0 | 0 |  |  | 2.00 | " |
| 17 | 221 | 1 | 0.45 |  |  | 2.00 | " |
| 18 | 220 | 0 | 0 |  |  | 2.00 | " |

Table IX shows that the greatest single mortalities occurred at times when the stream was clear, and the temperature range quite normal. The days when the creek was very muddy show no definite rises in mortality.

August 10th, 1950 is of special interest as the temperature taken early in the morning was eight degrees higher than the evening temperature. A violent hailstorm during the afternoon lowered the temperature rapidly but this seemed to have no effect on the hatchery trout.

le X. Transplanted Native Trout 1951 - Mortality - Stream Conditions.

| ate | Total No. Present | Mortality | | | Temperature | | Stream Level | Turbidity |
|---|---|---|---|---|---|---|---|---|
| | | Killed | Nat. | % | Min. | Max. | | |
| ly 23 | 29 | | | | 45 | 60 | 3.00 | Clear |
| 24 | 54 | | | | 47 | 61.5 | 2.75 | " |
| 25 | 81 | | | | 50 | 63.5 | 2.75 | " |
| 26 | 107 | 2 | | | 49 | 62 | 2.25 | " |
| 27 | 105 | 1 | | | 47 | 64 | 2.25 | " |
| 28 | 104 | 3 | 1 | 0.96 | 50 | 62 | 2.25 | " |
| 29 | 100 | 1 | | | 48 | 61 | 2.25 | " |
| 30 | 111 | | | | 49 | 63 | 2.00 | " |
| 31 | 124 | 2 | | | 49 | 63.5 | 2.00 | " |
| g. 1 | 122 | 1 | | | 51.5 | - | 1.75 | " |
| 2 | 121 | | | | 49.5 | 64 | 1.75 | " |
| 3 | 121 | | 1 | 0.82 | 49.5 | 64 | 1.75 | " |
| 4 | 120 | | | | 50 | - | 1.75 | " |
| 5 | 120 | | | | 50 | 57 | 1.75 | " |
| 6 | 120 | 1 | 1 | 0.83 | 44 | 56 | 1.75 | " |
| 7 | 118 | | | | 44 | 56 | 1.75 | " |
| 8 | 118 | | | | 48 | 55 | 1.75 | " |
| 9 | 118 | | | | 46 | 54 | 2.00 | Slightly murky |
| 10 | 118 | | | | 45 | 54 | 2.50 | " " |
| 11 | 118 | | | | 49 | - | 2.50 | Murky |
| 12 | 118 | | | | 48 | 50 | 4.00 | Very murky |
| 13 | 118 | | | | 47 | 50 | 3.50 | " " |
| 14 | 118 | | | | 42 | 48 | 3.00 | Slightly murky |
| 15 | 118 | | | | 47 | 58 | 2.50 | Clear |
| 16 | 118 | 1 | | | 46 | 58 | 2.25 | " |
| 17 | 117 | 2 | | | 45 | - | 2.00 | " |
| 18 | 115 | | | | 48 | 59 | 2.00 | " |
| 19 | 115 | | | | - | - | 1.75 | " |
| 20 | 115 | 2 | 2 | 1.72 | 40 | 57 | 1.50 | " |
| 21 | 111 | | | | 44 | 58.5 | 1.50 | " |
| 22 | 111 | | | | 46 | 48 | 1.50 | " |
| 23 | 111 | | | | 44 | 46 | 4.00 | Muddy |
| 24 | 111 | | | | 42 | 48 | 8.00 | " |
| 25 | 111 | | | | 41 | 47 | 5.25 | Very murky |
| 26 | 111 | 2 | | | 40 | 46 | 5.00 | " " |
| 27 | 109 | | | | 42 | 44 | 4.00 | Slightly murky |
| 28 | 109 | | | | 37.5 | 41 | 6.00 | Murky |
| 29 | 109 | | | | 40 | 41 | 14.00 | Muddy |
| 30 | 109 | | | | 40 | - | 17.00 | Very muddy |

Table X shows no correlation between mortality of native trout and stream conditions. All the natural mortality shown took place during low, clear water periods.

The fish listed under the heading of mortality in the column headed killed, were those that died attempting to return to the section from which they were transplanted. It was noted that these fish were continually attempting to force their way through the screens. The condition of the stream seemed to have no effect on this movement and several fish are known to have travelled through the screens during high water.

Table XI. Mortality of hatchery-reared trout as related to stream conditions - 1952.

| | Total No. | Mortality | | Temperature | | | |
|---|---|---|---|---|---|---|---|
| Date | Present | No. | % | Min. | Max. | Stream Level | Turbidity |
| ly 14 | 188 | 6 | 3.19 | 44.5 | 62 | 2.50 | Clear |
| 15 | 182 | 62 | 34.06 | 49 | 61 | 2.50 | " |
| 16 | 120 | 9 | 7.5 | 47 | - | 3.00 | " |
| 17 | 111 | 24 | 21.6 | 45 | - | 6.00 | " |
| 18 | 87 | 0 | 0 | 44 | 50 | 6.00 | Very murky |
| 19 | 87 | 0 | 0 | 45 | 52 | 6.00 | Murky |
| 20 | 87 | 2 | 2.29 | 44 | 50 | 5.50 | Clear |
| 21 | 85 | 2 | 2.35 | 42.5 | 50 | 5.50 | Slightly murky |
| 22 | 83 | 2 | 2.4 | 43 | 50 | 5.00 | Clear |
| 23 | 81 | 1 | 1.23 | 42 | 50 | - | Clear |
| 24 | 80 | 3 | 3.75 | 42 | 52.5 | - | Clear |
| 25 | 77 | 0 | 0 | 42 | 58 | 4.50 | Clear |
| 26 | 77 | 2 | 2.59 | 43.5 | 60 | 4.00 | Clear |
| 27 | 75 | 0 | 0 | 44 | 50.5 | 4.00 | Clear |
| 28 | 75 | 1 | 1.33 | 43.5 | 58.5 | 4.00 | Clear |
| 29 | 74 | 0 | 0 | 46 | 60.5 | 4.00 | Clear |
| 30 | 74 | 2 | 2.7 | 47 | 62 | 2.50 | Clear |
| 31 | 72 | 2 | 2.77 | 48 | 64 | 2.50 | Clear |
| g. 1 | 70 | 0 | 0 | 50 | 64 | 2.50 | Clear |
| 2 | 70 | 0 | 0 | 49 | 63 | 2.00 | Clear |
| 3 | 70 | 0 | 0 | - | 59 | - | Clear |
| 4 | 70 | 2 | 2.85 | 47 | - | - | Clear |
| 5 | 68 | 0 | 0 | - | - | 1.50 | Clear |
| 6 | 68 | 0 | 0 | 46.5 | 59.5 | 1.00 | Clear |
| 7 | 68 | 0 | 0 | 46 | 51 | 3.00 | Clear |
| 8 | 68 | 0 | 0 | 47.5 | 57 | 1.50 | Clear |
| 9 | 68 | 0 | 0 | 49 | - | 9.50 | Muddy |
| 10 | 68 | 1 | 1.47 | 48 | 52 | 13.00 | Very Muddy |
| 11 | 67 | 0 | 0 | 43 | 58 | 13.00 | " " |
| 12 | 67 | 0 | 0 | 46 | 55 | - | " " |
| 13 | 67 | 0 | 0 | 45.5 | - | - | " " |
| 14 | 67 | 1 | 1.49 | 47 | 51.5 | 12.00 | " " |
| 15 | 66 | 0 | 0 | 45 | - | 11.00 | Muddy |
| 16 | 66 | 0 | 0 | 44 | 55 | 8.50 | " |
| 17 | 66 | 0 | 0 | 43 | 57.5 | 8.00 | Very murky |
| 18 | 66 | 0 | 0 | 45 | 59 | 7.50 | " " |
| 19 | 66 | 0 | 0 | 43 | 58 | 7.50 | Murky |
| 20 | 66 | 0 | 0 | 44 | 54 | - | " |
| 21 | 66 | 0 | 0 | 43 | 55 | 4.00 | Slightly murky |
| 22 | 66 | 0 | 0 | 44.5 | 54 | - | Clear |
| 23 | 66 | 1 | 1.51 | 47 | 54 | 4.00 | " |
| 24 | 65 | 0 | 0 | - | - | 4.00 | " |
| 25 | 65 | 0 | 0 | 47 | 54 | 4.00 | " |

Table XI. Concluded.

| | Total No. | Mortality | | Temperature | | | |
|---|---|---|---|---|---|---|---|
| Date | Present | No. | % | Min. | Max. | Stream Level | Turbidity |
| g. 26 | 65 | 0 | 0 | 43 | 50 | - | Clear |
| 27 | 65 | 0 | 0 | 40 | - | - | " |
| 28 | 65 | 0 | 0 | - | 51 | 4.00 | " |
| 29 | 65 | 0 | 0 | 40 | 50 | 4.00 | " |
| 30 | 65 | 0 | 0 | 39.5 | 52 | 4.00 | Muddy |
| 31 | 65 | 0 | 0 | 40.5 | 50 | 5.00 | Murky |
| pt. 1 | 65 | 0 | 0 | 39 | - | 4.50 | " |
| 2 | 65 | 0 | 0 | - | - | 3.50 | Slightly murky |
| 3 | 65 | 0 | 0 | - | - | 2.00 | " " |
| 4 | 65 | 0 | 0 | - | 49 | 1.50 | Clear |
| 5 | 65 | 0 | 0 | 38.5 | 50 | 1.00 | " |
| 6 | 65 | 0 | 0 | 39 | 52 | 1.00 | " |
| 7 | 65 | 0 | 0 | 41.5 | 49 | 0.00 | " |
| 8 | 65 | 1 | 1.53 | 41 | 46.5 | 0.00 | " |
| 9 | 64 | 0 | 0 | 41 | 43 | 0.00 | " |
| 10 | 64 | 0 | 0 | 40 | 47 | 0.00 | " |

Table XI shows the stream conditions in 1952 and the mortality of hatchery-reared trout with the absence of competition from wild trout.

The great mortality evidenced by this group of fish in the first four days took place while the creek was low and clear. The subsequent rise in water level and turbidity had no marked effect on mortality although the increase in rate of flow probably hastened the death of a few weak individuals.

During the very high water from August 9th to August 16th only two fish died.

It seems evident from interpretation of the preceding tables that increases in water level and turbidity have little or no effect on survival of native or hatchery-reared trout. The temperature range in the creek does not appear to affect survival in either group of fish. The temperatures generally show a quite regular daily fluctuation depending on air temperatures and cloud cover. Thus none of the factors listed in Tables IX, X, and XI appear to have any noticeable effect on mortality in trout populations.

## DISCUSSION

Research workers in the United States have carried out survival experiments on various species of trout. Different results were obtained in most cases; the returns to the angler of spring planted legal sized fish varied from 5 percent to 50 percent but the great majority of experiments showed returns of around 30 percent. With very few exceptions the returns from fall planted fish are negligible. This suggests that the planted fish fail to survive over the winter. Thus it appears that the only way in which planting of trout reared under the present hatchery system can be at all feasible is with spring planting of legal sized trout. These fish must then be caught during the few months following planting or their value to the stream will be lost.

The work done by Mangan in 1950 shows that the problem is very much the same in Alberta as in the United States. The Lot I (three-year-old) trout planted in 1950 suffered a 30.1 percent mortality over the summer months and only two survivors were contacted in Gorge Creek the following summer. Thus the total survival of Lot I fish over the winter of 1950-51 was one percent.

The Lot II (two-year-old) fish suffered a mortality of 87 percent during the summer months and none of this group survived the winter.

The mortality in both groups of fish was noted to be from two causes and took place at different times. The first and largest mortality was immediate and was apparently due to exhaustion. In both groups of fish many seemed unable to manoeuver in the current and drifted helplessly downstream to the lower screen. Many fish were noticed in the pool immediately above Number I screen, and each day several would succumb to the current and die on the screen. After the initial mortality of these weaker members of the population very few dead fish were found for several weeks. However, the weight checks obtained on the survivors revealed that the majority were losing weight quite rapidly and apparently not feeding.

The Lot II (two-year-old) fish were most drastically affected by the weight loss and most of these fish died before the end of the summer. The larger three-year-old trout began to regain lost weight after 55 days but were unable to reach peak condition before winter set in. Due to their slightly weakened condition very few were able to survive the rigors of winter.

Thus the main causes of mortality seemed to be, inability to navigate in the fast flowing water, and unfamiliarity with natural food and a consequent lapse in feeding. It was also suspected that competition for food with native trout was a factor in the secondary mortality.

Since many of the workers in the United States had suggested the hatchery environment as a primary cause of mortality, several experiments were attempted in order to prove or disprove the effect of various aspects of hatchery influence.

All the hatcheries in operation in Alberta at present provide pools in which the fish live for two to three years before planting. The fish are fed regularly by attendants, on a diet of specially prepared food. The water is kept fresh by constant movement in and out of the pool but the fish are never subjected to any noticeable current. As fry they are fed ground hogs' liver and when they reach the fingerling stage the diet is changed to ground meat with a cereal supplement. Neither of these foods resemble the natural food encountered in a stream.

The experiment with fish raised in swiftly flowing water and with a natural food supply (Section IV) shows conclusively that pond rearing and artificial food

are definite causes of mortality. The Bighill reared fish suffered no initial mortality due to stream conditions and the weight losses in this group were negligible. Thus it seems evident that these fish were not only quite capable of recognizing natural food but were also well accustomed to the current and thus showed no noticeable mortality. However, it must be remembered that only 58 of the original 600 fish placed in Bighill Creek were recovered. Although this sounds like a heavy loss, the fry planted in Bighill Creek had at that time cost very little to raise and from that time on cost nothing. The survival of these fish throughout the summer indicates that several should spawn this coming summer and thus contribute further to the population of Gorge Creek. However, this assumption should be proven or disproven during the summer of 1953. Whether or not any of the Bighill fish survive, they are still a more suitable fish to use for "put and take" plantings. The Bighill reared fish were far more active and much more difficult to catch than the very slow moving, "lifeless" pond reared trout.

The experiment with hatchery-reared trout planted in the section from which the native population had been removed (Section III), indicates that competition

has no effect on the first wave of mortality but does influence subsequent weight losses.

Thus it would seem that the weight losses suffered by the planted pond reared trout are due to two factors. The first is the fact that the individuals who do not succumb to the current are nevertheless weakened by the change from pond to stream and are consequently unable to compete with native trout. This is illustrated by the fact that the fish without competition showed far smaller weight losses than those with native competition. The second factor appears to be the unfamiliarity of the planted fish with natural food. As has been previously stated, the ground meat fed to fish in the hatchery, in no way resembles the May-fly nymphs, Caddis larvae and various adult insects found in or on the surface of a stream.

The result of the experiment on overpopulation of a section of stream with tagged native trout (Section II) further substantiates the assertion that competition is a factor in weight losses of planted trout. The native fish did show a slight loss in weight, undoubtedly due to the fact that population of the particular section was nearly doubled.

Tagging and handling has been mentioned by many writers as a possible cause of mortality but the

results of experiments described in Section II and Section IV seem to prove this is not the case. All the fish described in these experiments were individually weighed, tagged and moved in containers from place to place, in much the same way as pond reared fish. No mortality due to handling or tagging was recorded in either case.

The final section of this work gives a list of stream conditions in Gorge Creek for the days during which tagged fish were under observation in the creek in 1950, 1951 and 1952. The mortality due to the causes already discussed seems to occur regardless of stream conditions and no correlation can be made between mortality of planted trout and water level, stream temperatures or turbidity. In this regard, it is of interest to note that many of the tagged native fish and one of the Bighill reared trout were observed attempting to travel upstream through the screens in the midst of flood conditions accompanied by very high turbidity.

## CONCLUSIONS

1. If fish-tight screens had not been present, the majority of the pond reared trout would have drifted out of the stream in the first few days.

2. The cause of the primary mortality suffered by hatchery-reared trout is their inability to adjust themselves to swift water.

3. The cause of the secondary mortality is their refusal or inability to feed on natural food. The reasons for this are:

(a) They may not recognize the natural food after the artificial food provided them in the hatchery.

(b) They are not physically capable of competing with wild native trout for natural food.

(c) The native trout present in the stream are making maximum use of the food supply available. Thus any addition to the population causes a slight decrease in food supply for the rest of the fish.

4. Increasing the population in a given section of stream by the addition of wild native fish causes no mortality but does cause a slight loss in weight in the population as a whole.

5. Trout hatched in the same way as hatchery-reared fish and then placed in natural surroundings, e.g., fast water with a natural food supply, do not suffer the initial mortality and only very slight weight losses occur.

6. Handling and tagging of trout has no effect on mortality of these fish.

7. In the period during which the fish were under observation, the stream conditions, e.g., water level, temperature, and turbidity, had no effect on mortality.

8. The planting of fish reared by present hatchery methods in Alberta streams is uneconomical and does not contribute to the brood stock of the stream.

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